

154. The semiconductor device according to claim 111 wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$.

155. The semiconductor device according to claim 111 wherein the second thin film transistor is one of a p-channel thin film transistor having a mobility in a range of 200-400 cm^2/Vs and an n-channel thin film transistor having a mobility in a range of 500-1000 cm^2/Vs . --

REMARKS

At the outset, the Examiner is thanked for the review and consideration of the present application.

The Examiner's Office Action dated September 25, 2001 has been received and its contents reviewed. Prior to this amendment, claims 73-144 were pending. By this Amendment, claims 73, 80, 87, 93, 99, 105, 111, 123, and 129 have been amended, claims 117-118 and 120-122 have been canceled, and new claims 145-155 have been added. Accordingly, claims 73-116, 119, and 123-155 are pending in the present application, of which claims 73, 80, 87, 93, 99, 105, 111, 123, and 129 are independent.

Referring now to the Office Action, claims 73-144 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Zhang ('733, '360, or '426) in view of Yamazaki ('636) as previously rejected. The Examiner asserted that the new limitations do not structurally distinguish over the prior art where, in Zhang '426, a field mobility of a NOS transistor is disclosed. The particular field of mobility of a NOS transistor claimed inherent in the prior art or would have been routine experimentation for one of ordinary skill seeking to maximize device function.

Applicants respectfully traverse the rejection at least for the reasons provided below.

The primary feature of the presently claimed invention is that a channel region is formed in a monodomain region. In other words, the channel region has substantially no grain boundary.

As shown in Fig. 2A of the present application, after performing a crystallization step, the semiconductor film has a plurality of monodomain regions 103, 104, and 105. An active layer 106, which includes a channel region, is formed in one monodomain region, and, therefore, the channel region has no grain boundary. The monodomain region, however, has point defects which are neutralized by at least one of hydrogen or a halogen contained in a concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$.

The semiconductor film, as crystallized in accordance with the method of the present invention, actually does include grain boundaries, as shown in Fig. 2A and Fig. 7. Nevertheless, the distinguishing feature of the presently claimed invention resides in the formation of the active layer or the channel region within one monodomain region which contains no grain boundary.

The Examiner contends that the crystallization method disclosed in the above-cited prior art references are so similar to the presently claimed invention that the crystallinity disclosed in the presently claimed invention is inherently achieved in the cited prior art references. In other words, the Examiner's argument is that the crystallized semiconductor film of the cited prior art references must include the same crystallinity as the film formed in the present invention. However, even if the Examiner is correct, the crystallized semiconductor film of these references must include grain boundaries because the crystallized semiconductor film of the present invention includes them as shown in Fig. 2A and Fig. 7. None of the cited references specifically teach, disclose, or suggest how to arrange or form a channel region in a portion of the film with no grain boundaries. As a result, even if it could be shown that the semiconductor film disclosed by the cited references is the same as the film provided by the present invention, the references fail to teach the placement of the channel region in a portion without grain boundaries.

Moreover, Applicants note the Examiner's reliance upon Zhang '360 as teaching, in col. 10, lines 45-49, that "because a direction into which carriers flow and the direction of crystal growth coincide in the structure described above, the carriers do not cross the crystal boundary when moving." However, Applicants respectfully submit that this teaching does not imply that the channel has no grain boundary. Rather, this teaching implies that there are grain boundaries in the channel region but these grain

boundaries do not affect the carrier flow because the carriers flow along, but not across, the grain boundaries. As a result, the Office Action fails to point to a single disclosure or suggestion of positioning a channel region in a monodomain region of a semiconductor film.

In view of the foregoing amendments and arguments, Applicants respectfully request reconsideration and withdrawal of the U.S.C. § 103(a) rejection of claims 73-144.

New dependent claims 145-155 have been added to further complete the scope of the invention to which Applicants are entitled; and, claims 73, 80, 87, 93, 99, 105, 111, 123, and 129 have been amended to clarify the claim language and to further complete the scope of the invention to which Applicants are entitled.

CONCLUSION

Having responded to all rejections set forth in the outstanding non-Final Office Action, it is submitted that claims 73-116, 119, and 123-155 are now in condition for allowance. An early and favorable Notice of Allowance is respectfully solicited. In the event that the Examiner is of the opinion that a brief telephone or personal interview will facilitate allowance of one or more of the above claims, the Examiner is courteously requested to contact Applicants' undersigned representative.

Respectfully submitted,



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MARKED UP VERSION OF AMENDED CLAIMS

73. (Thrice Amended) A thin film transistor comprising:
a crystalline semiconductor island over a substrate having an insulating surface;
source and drain regions in said semiconductor island;
a channel forming region between said source and drain regions;
a gate insulating film adjacent to at least said channel forming region;
a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,
wherein said channel forming region has no grain boundary, and
[wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,]
wherein said semiconductor island includes a spin density not higher than $1 \times 10^{17} \text{ cm}^{-3}$,
wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing a point defect in the crystalline semiconductor island,
wherein the thin film transistor, is a p-channel thin film transistor or an n-channel thin film transistor,
wherein the p-channel thin film transistor has a mobility in a range of $200\text{-}400 \text{ cm}^2/\text{Vs}$ while the n-channel thin film transistor has a mobility in a range of $500\text{-}1000 \text{ cm}^2/\text{Vs}$].

80. (Twice Amended) A thin film transistor comprising:
a crystalline semiconductor island on an insulating surface;
source and drain regions in said semiconductor island;
a channel forming region between said source and drain regions;
a gate insulating film on at least said channel forming region;

a gate electrode over said channel forming region having said gate insulating film therebetween,

wherein said channel forming region has no grain boundary, and

[wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,].

wherein said semiconductor island includes a point defect of $1 \times 10^{16} \text{ cm}^{-3}$ or more, and at least one of hydrogen and halogen element [for neutralizing the point defect] at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$],

wherein the thin film transistor is a p-channel thin film transistor or an n-channel thin film transistor,

wherein the p-channel thin film transistor has a mobility in a range of $200\text{-}400 \text{ cm}^2/\text{Vs}$ while the n-channel thin film transistor has a mobility in a range of $500\text{-}1000 \text{ cm}^2/\text{Vs}$].

87. (Amended) A semiconductor device comprising:

a crystalline semiconductor island on an insulating surface;

source and drain regions in said semiconductor island;

a channel forming region between said source and drain regions;

a gate insulating film adjacent to at least said channel forming region;

a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

[wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,]

wherein said crystalline semiconductor island is formed in a monodomain region which contains no grain boundary,

wherein at least one of hydrogen and halogen element is contained at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island],

wherein the semiconductor device includes [at least one selected from the group consisting of a p-channel thin film transistor and an n-channel thin film transistor,

wherein the] a p-channel thin film transistor [has] having a mobility in a range of $200\text{-}400\text{ cm}^2/\text{Vs}$ [while the n-channel thin film transistor has a mobility in a range of $500\text{-}1000\text{ cm}^2/\text{Vs}$].

93. (Amended) A semiconductor device comprising:

a crystalline semiconductor island on an insulating surface;
source and drain regions in said semiconductor island;
a channel forming region between said source and drain regions;
a gate insulating film adjacent to at least said channel forming region;
a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

[wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18}\text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19}\text{ cm}^{-3}$,]

wherein said channel forming region is formed in a monodomain region which contains no grain boundary,

wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20}\text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island],

wherein the semiconductor device includes at least one [selected from the group consisting of a p-channel thin film transistor and an] n-channel thin film transistor[,

wherein the p-channel thin film transistor has a mobility in a range of $200\text{-}400\text{ cm}^2/\text{Vs}$ while the n-channel thin film transistor has] having a mobility in a range of $500\text{-}1000\text{ cm}^2/\text{Vs}$.

99. (Twice Amended) A semiconductor device comprising:

a p-channel thin film transistor;

an n-channel thin film transistor;
each of said p-channel thin film transistor and said n-channel thin film transistor comprising:

a crystalline semiconductor island on an insulating surface;
source and drain regions in said semiconductor island;
a channel forming region between said source and drain regions;
a gate insulating film adjacent to at least said channel forming region;
a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

[wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,]

wherein said crystalline semiconductor island is formed in a monodomain region which contains no grain boundary,

wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island,

wherein the p-channel thin film transistor has a mobility in a range of $200\text{-}400 \text{ cm}^2/\text{Vs}$ while the n-channel thin film transistor has a mobility in a range of $500\text{-}1000 \text{ cm}^2/\text{Vs}$].

105. (Twice Amended) A semiconductor device comprising:

a p-channel thin film transistor;
an n-channel thin film transistor;
each of said p-channel thin film transistor and said n-channel thin film transistor comprising:

a crystalline semiconductor island on an insulating surface;
source and drain regions in said semiconductor island;
a channel forming region between said source and drain regions;
a gate insulating film adjacent to at least said channel forming region;

a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

wherein said crystalline semiconductor island includes carbon [and nitrogen] at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,

wherein said channel forming region is formed in a monodomain region which contains no grain boundary,

wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island,

wherein the p-channel thin film transistor has a mobility in a range of 200-400 cm^2/Vs while the n-channel thin film transistor has a mobility in a range of 500-1000 cm^2/Vs].

111. (Twice Amended) A semiconductor device [including an electro-optical device] comprising:

an active matrix circuit portion including at least a first thin film transistor;

a [peripheral] driving circuit portion including at least a second thin film transistor;

said second thin film transistor comprising:

a crystalline semiconductor island on an insulating surface;

source and drain regions in said semiconductor island;

a channel forming region between said source and drain regions;

a gate insulating film adjacent to at least said channel forming region;

a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

[wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,]

wherein said crystalline semiconductor island is formed in a monodomain region which contains no grain boundary,

wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island,

wherein the semiconductor device includes at least one selected from the group consisting of a p-channel thin film transistor and an n-channel thin film transistor,

wherein the p-channel thin film transistor has a mobility in a range of $200\text{-}400 \text{ cm}^2/\text{Vs}$ while the n-channel thin film transistor has a mobility in a range of $500\text{-}1000 \text{ cm}^2/\text{Vs}$].

123. (Twice Amended) A semiconductor device comprising:

a crystalline semiconductor island on an insulating surface;

source and drain regions in said semiconductor island;

a channel forming region between said source and drain regions;

a gate insulating film adjacent to at least said channel forming region;

a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, [and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$],

wherein said crystalline semiconductor island is formed in a monodomain region which contains no grain boundary,

wherein said semiconductor device has a S value of 0.03-0.3,

wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island],

wherein the semiconductor device includes at least one selected from the group consisting of a p-channel thin film transistor and an n-channel thin film transistor,

wherein the p-channel thin film transistor has a mobility in a range of 200-400 cm^2/Vs while the n-channel thin film transistor has a mobility in a range of 500-1000 cm^2/Vs .

129. (Twice Amended) A semiconductor device comprising:

- a crystalline semiconductor island on an insulating surface;
- source and drain regions in said semiconductor island;
- a channel forming region between said source and drain regions;
- a gate insulating film adjacent to at least said channel forming region;
- a gate electrode adjacent to said channel forming region having said gate insulating film therebetween,

wherein said crystalline semiconductor island includes carbon and nitrogen at a concentration not higher than $5 \times 10^{18} \text{ cm}^{-3}$, [and oxygen at a concentration not higher than $5 \times 10^{19} \text{ cm}^{-3}$,]

wherein said channel forming region is formed in a monodomain region which contains no grain boundary,

wherein said semiconductor device has a S value of 0.03-0.3,

wherein said crystalline semiconductor island includes at least one of hydrogen and halogen element at concentration not higher than $1 \times 10^{20} \text{ cm}^{-3}$ [for neutralizing point defects in the crystalline semiconductor island],

wherein the semiconductor device includes at least one selected from the group consisting of a p-channel thin film transistor and an n-channel thin film transistor,

wherein the p-channel thin film transistor has a mobility in a range of 200-400 cm^2/Vs while the n-channel thin film transistor has a mobility in a range of 500-1000 cm^2/Vs .